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Inside: Collaboration at its Best: The Casper Museum Consortium

Plus: Pop-up Exhibits, Designing for Creativity, and What we Can Learn from Closed Museums

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Designing for Creativity and Innovation in Informal Science Learning

By Rachel Kendal, Jeremy Kendal, Zarja Mursic, Claire Bailey-Ross, Hannah Rudman, Andy Lloyd, and Bethan Ross

Informal Science Learning practitioners develop their activities in order to improve people's confidence around science, their understanding of the scientific approach, and their appreciation of the results of scientific enquiry. Observing, collecting evidence, testing, applying logic and analyzing data are all core scientific skills encouraged in science centers. However, some people love the arts, sports, or humanities and are more likely to identify with another set of interesting activities: creativity, innovation, discussing and designing. Of course, this second list also describes core scientific skills. There are many initiatives that aim to excite people so that they come to love science as much as they love the arts, humanities and sports. Many practitioners, however, have an exclusive focus on the sciences, with the result that a great many people are turned off at a young age by a subject that they cannot personally identify with (DeWitt et al., 2013).

Science uptake in UK schools and universities is currently experiencing a dramatic downturn (Swan, 2013). Researchers at Durham University[1] and science educators at the UK's Centre for Life[2] are investigating whether developing creativity and innovation offers a different route into STEM subjects that can also incorporate other subjects and forms of inquiry. External researchers and internal science center practitioners formed a multi-disciplinary team to co-produce exhibits, which enhance creativity, innovation and scientific thinking.

BACKGROUND

University researchers in cultural evolution and child development are steadily gaining new insights into the intricacies of children's reasoning and scientific thinking. At the same time, there has been increased recognition of the important role that visits to informal learning institutions, like science centers, play in supporting science learning. Traditionally, academic research and science center practice typically unfold independently with different aims, objectives and methods. The disconnect between these activities can make it difficult to identify meaningful intersections between academic research and educational practice in informal settings.

Researchers at Durham University and science educators at the UK's Centre for Life are working together to blur the boundary between research and practice. In this project we document and discuss a multi-disciplinary partnership between university researchers and science center practitioners, which is resulting in the co-production of science exhibits which are intended to enhance creativity, innovation and scientific thinking in those that interact with them. Of particular interest for the project is consideration of how engaging with informal educators influences the research process, and how engaging with researchers influences the work of informal educators. A complementary focus is on the cutting edge process of designing exhibits for creativity and innovation in scientific thinking when they are co-produced by researchers and science center practitioners in informal learning settings.

The Durham University researchers have developed insight into how humans learn novel tasks and the importance of social transmission, including cumulative culture (Dean et al., 2012); the study of social transmission in naturalistic contexts (Kendal et al., 2010) and the tradeoffs made between learning from others and individual innovation (Wood et al., 2013; Carr et al. 2015); how social and environmental factors (Flynn et al., 2013) play a significant role in influencing the tendency to learn for oneself (and potentially innovate) or copy others; and quantitative methods to identify signatures of social learning and innovation in informal learning environments (Kendal et al., 2009). The balance between accepting information from another, versus testing hypotheses for oneself, through creative exploration, is at the heart of the scientific enterprise (Feynman, 1969).

From this base of knowledge, the researchers are keen to further examine how individuals learn in informal learning environments. The particular focus of the experiments in the exhibit will look for factors that influence the tendency of an individual to solve problems by copying others or by experimenting, innovating and testing their own novel and creative solutions. The researchers will also investigate the nature of research, participation, engagement, and creativity possibilities that can be provided by digital technology (Ross et al., 2013). In tandem, the practitioners from Centre for Life are keen to apply recent psychological, anthropological, education, and design theory to exhibit design, as well as experimenting with whether novel digital information systems could become resilient research tools. Together, we are aligning research and practice objectives and through a process of co-producing exhibits, exploring what we can learn from each other.

The team collaborated through a process of participatory action research. Throughout 2015, the team held a number of design workshops and meetings. At them, they applied both academic theory and craft practice to iteratively prototype novel interactive exhibit designs specifically to encourage creativity and innovation (Rudman et al., 2015). A key focus was also ensuring creativity and innovation could be measured accurately. The new exhibit(s) resulting from this co-design and participatory action research process will form part of the Brain Zone exhibition opening at the Centre in spring 2016. In the Brain Zone, visitors will find out how scientists explore the brain's inner workings and take part in live experiments that reveal some of its capabilities.

In October 2015, during a busy visitor week at the Centre for Life, the team piloted the prototype of the new exhibit. They tested multiple visitor learning experiments, the digital research tools, and how best to gain ethical consent from visitors participating in the research. In this article we begin to explore the process for designing for creativity and innovation in informal science learning environments, by presenting a case study from the Centre for Life. We discuss the key design criteria and research processes that drove the development of the exhibit, and summarize the iterative development process used to build the prototype. We report lessons learned, as well as initial findings, from the Centre for Life pilot study, which will be used to further develop the final exhibit to enhance creativity, innovation and scientific thinking.

EXHIBIT DESIGN

The exhibit (Figure 1) is a creative activity, a construction task with building blocks. Constructed from sturdy MDF, metal poles, and wood, the exhibit has three user stations and allows three different experimental conditions. Each user station has a horizontal activity surface 400mm deep, onto which loose items can be placed, and space to fit a touchscreen tablet housed on a secure stand. There are 1500mm tall vertical partitions, surrounding the table, to shield the activity from outside observers. Overhead, a truss structure supports the lighting for the exhibit. Reconfigurable partitions 500mm tall between the user stations (here shown in their transparent state) allow for the following test conditions:

- a single user working on his or her own, unable to see other users (who will be performing a similar task at an adjacent user station but separated by opaque partitions);
- a single user working on his or her own, but able to see what other people are doing at other user stations (but not necessarily interact with them due to transparent partitions as seen in Fig. 1); and
- several users able to work together across the user stations (no partitions).

Figure 1: The prototype exhibit.

The quality of presentation of the exhibit was not important at this pilot stage, so "test area" signs and a cordoned off zone created with hazard tape presented a credible but basic experience (Figure 2). Users of the exhibit were simply asked to "build your best building" using the 100 wooden blocks in each station.

Figure 2: Test area signage.

DESIGNING THE DIGITAL RESEARCH TOOLS

In order to improve data capture and collection, the exhibit has built-in digital research tools and information systems that can be used to both gather ethical consent and capture data about user interaction and experience. Underneath the user stations, a small lockable cupboard houses power cables for touchscreen tablets and video cameras, routers and switches, a PC, and a 3TB hard drive. The metal poles within each user station provide mounting points for Internet Protocol (IP) cameras to capture individual user behavior, as well as the status of the tablets' screens which are used to gain ethical consent (Figure 4). Another IP camera is mounted above the center of the pod to capture an overview for cross-reference. Power cables for the user station cameras run down the insides of the metal poles. The IP cameras are connected to a Network Video Recorder (NVR) stored in the locked cupboard. Usually used for building security surveillance, the NVR and IP camera system is also suitable for research purposes. It creates a secure local area network to allow researchers to log-in to control the cameras, and view recordings or live footage (Fig. 3). It also has an intuitive, configurable, and feature packed user interface with advanced features such as motion detection, auto discovery, user-level security, storage management, reporting, and mobile device support.

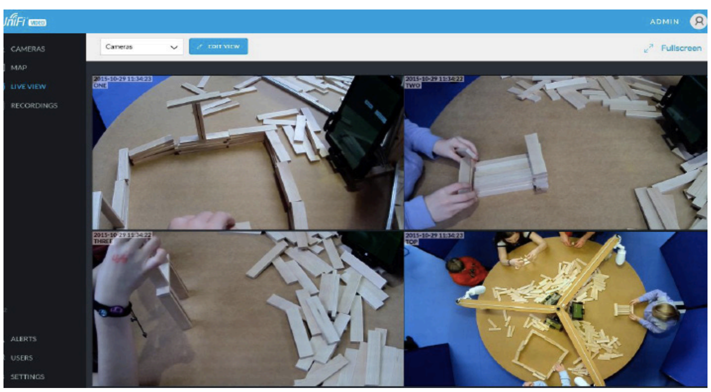

Figure 3: Digital research tools capture user activity.

The system is easy to set up each day. The NVR system turns on by itself with the exhibition power-up in the morning. The cameras record from that point on for the rest of the day. At the end of the day the system is turned off manually to ensure the captured data saves to the hard drive kept locked onsite in the cupboard under the exhibition pod. The tablets, which host the consent form and the activity instructions, need switching on manually, but automatically boot into the online consent system in a kiosk mode (i.e. it only allows access to the consent system). The tablets run on main power, so are also on all day.

Each tablet runs its own consent survey to enable linking with the corresponding camera, of that particular user station (Figure 4). The cameras and consent system have a shared timestamp, so this can be cross-referenced to ensure use of only footage for which Centre visitors have granted consent. In addition, and for ease at the data analysis stage, the cameras record the permission screen. Only footage showing the tablets with green or yellow screens is kept for research purposes (red tablet screens indicate that participants have completed the ethical consent survey on the tablet and declined permission for their data to be used in the study). A cloud-based open source software survey system (Limesurvey[3]) was used to seek ethical consent. A series of questions required user responses through check boxes and buttons, which could be easily and quickly navigated using the tablets' touchscreens. The wording of the consent form was agreed in advance by Durham University's ethical consent board and followed the British Psychological Society's guidelines for internet mediated research.

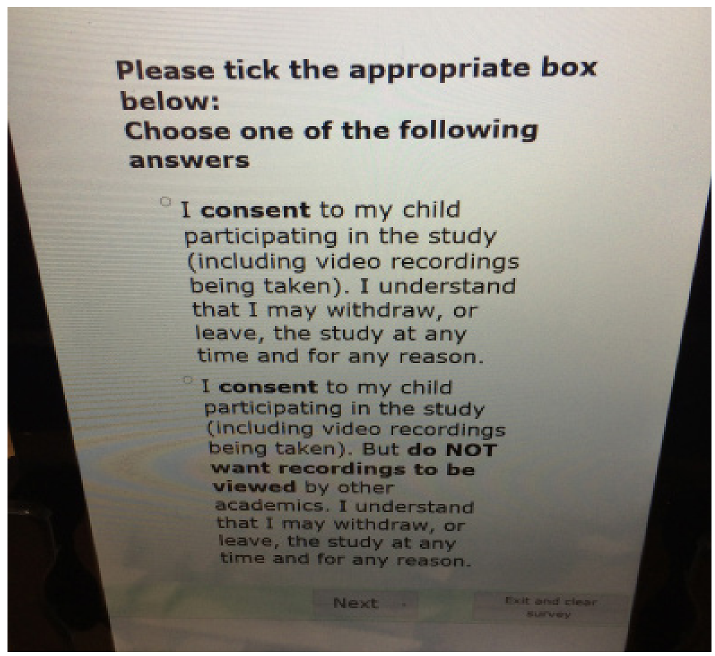

Figure 4: Tablet running the online ethical consent form.

FINDINGS FROM PILOTING THE PROTOTYPE EXHIBIT

Through observing the prototype exhibit heavily in use (231 participants with consent, and many more whom interacted with the exhibit), the team learned a number of practical lessons that will now be fed into the final exhibit design as a further iteration. The simple instruction to "build your best building" worked adequately to prompt a broad range of creative and innovative constructions, and we noted high dwell times at the exhibit. The video footage collected by the IP cameras and NVR system was of excellent quality, ensuring coding of the data will be accurate. However, sometimes the process and results of the activity were hard to see in the footage, as visitors obstructed the cameras as they crowded around the activity.

Removable cut-outs in the table surface would encourage a single child to focus in on the activity, and a marked build space on the table would ensure the cameras could see the construction activity and final building.

Footage from the pilot activity will be used to establish coding criteria for the analysis of levels of creativity and innovation in user activity and results within the final exhibit. Informal discussion with participants also indicated that the prototype made for an attractive exhibit in the Science Centre. Parents and guardians were intrigued by the research and team's aims, while participating children were excited and, it seemed, enthused by the thought of taking part in "real science." Formal qualitative research into these findings, and their potential impact on children, will take place once the final exhibit is in place.

CONCLUSION

The ultimate aim of the exhibit is to maximize the impact of informal science learning opportunities available to the general public and provide evidence of what design features in exhibits facilitate successful informal science learning. The prototype exhibit has gone some way to understanding how the design of an activity influences the levels of creativity and innovation the activity inspires. The digital research tools designed into the exhibit have provided a novel and user-friendly way of using information systems to capture user data, ethical permission, experiment results, and user activity for analysis.

Participatory action research has provided a method for the team to blend academic knowledge and practical know-how, and design thinking approaches have enabled the rapid design, development and prototyping of the exhibit and its experiments. Building upon this foundation, several promising directions remain for future work when looking at co-producing exhibits for enhancing creativity and innovation in informal science learning environments. First, we plan to further extend and refine the exhibit development to promote active prolonged engagement (Humphrey et al, 2005), as revealed by learners' dwell times, interaction patterns, and behavior. Further, we intend to expand the exhibit to reflect the myriad complexities of scientific thinking and decision making in this informal learning environment. In addition, we plan to conduct further studies examining cultural evolution and child development theory through activities in informal science learning environments involving naturalistic deployment with the public. The outputs of this work will result in policy documents and guidelines regarding exhibit design, specifically tailored for informal science learning practitioners, as well as new academic theory and novel contributions to the practice of research.

END NOTES

[1] Durham University website: http://www.dur.ac.uk; Project website: https://www.dur.ac.uk/esrciaa/test/researchingtogether/sciencelearning/.

[2] Centre for Life website: http://www.life.org.uk.

[3] Lime Survey open source software: http://www.limesurvey.org.

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Impacts vs. Benefits: How Well Do Yours Align?

By John W. Jacobsen

[This article is derived from the new book by John W. Jacobsen with a foreword by Ford W. Bell, *Measuring Museum Impact and Performance: Theory and Practice*, published in March 2016 by Rowman and Littlefield.]

Are your supporters and audiences getting benefits that are different from the impacts your mission desires? I believe that museums are valued for a wealth of beneficial results beyond their focused missions, and that studying the alignment between a museum's intentions and its results can improve a museum's impact and performance.

IMPACTS AND BENEFITS

A museum aspires to have *impacts* on its community, audiences and supporters. The community, audiences and supporters receive *benefits* from the museum. Impacts are the desires of the museum; benefits are in the eyes of the beneficiary.

The benefits can be different from the impacts: A family visiting an aquarium receives the benefit of a quality family experience, while the aquarium's impact on the family is to heighten their awareness of conserving biodiversity. Alternatively, the benefits and impacts can be aligned: New parents bring their toddler to a children's museum to see her develop and learn with new kinds of challenges; the children's museum's mission is also child development. Studying the alignment between a museum's benefits and impacts may illuminate potentials and inefficiencies.

A museum's value lies in its impacts, says museum sage Stephen E. Weil (Weil, 2005). However, the museum's value is expressed in terms of the value of the benefits. Since value is in the eye of the receiver, any valuation must first track the value the community and its audiences and supporters place on their perceived benefits. When the desired impact is the same as the perceived benefit, such as the children's museum example, then they are aligned. When they are different, such as the aquarium example, they are unaligned. Some degree of unalignment may be desirable for strategic or advocacy reasons, but too much may be inefficient and unsustainable.

EXCHANGES AS INDICATORS OF VALUE

Museums are free-choice marketplace organizations. No one must go to, pay admissions or fund a museum. People and organizations choose to spend time, effort and money on their museum engagements in exchange for perceived benefits. Your museum earns these value exchanges in a competitive economy: There are plenty of alternative missions, programs and leisure activities competing for your audiences and supporters.

A museum's *perceived value* is a qualitative judgment of the value of the benefits and impacts from engaging with the museum's activities by its community, audiences and supporters. Exchanged value is a quantification of the amount of time, effort and/or money actually exchanged for the benefits they received. *Exchanged* value can be an indicator of perceived value.

How can we measure these exchanges? We need to start with definitions (Jacobsen 2016), then we can measure consistently using terms that strengthen your measurements and analysis.

A *museum engagement* is defined as one physical person-trip to a museum or a museum sponsored program off-site by a person not employed or contracted by the museum to be there. The person-trip is a measure of *effort*